EXHIBIT O:

Claim Chart for Qualcomm Inc.

DHS; S&T Directorate; "Cell-All" Request: Adding the 1ˢᵗ Ind. claim of the 1ˢᵗ Patent '497 issued to the Complainant (filed 04-05-06), illustrates infringement of Complainant's claimed invention the same as: Ind. claim 1 of the '189 Patent; Ind. claim 22 of the '439 Patent; and, Ind. claim 5 of the '287 Patent. An example of the infringement is demonstrated below in a claim chart using the specifications of Qualcomm Inc. (i.e. Qualcomm is representative of the specifications of LG, Apple, and Samsung) for the development, manufacture, and commercialization of a Cell-All "WMD Electronic Detection Device". The *Synkera "MikroKera Ultra"* **integration with the Electronic Detection Device is also added.**

Qualcomm: Electronic Detection Device	Patent #: 10,163,287; Independent Claim 5	Patent #: 9,589,439; Independent Claim 22	Patent #: 9,096,189; Independent Claim 1	Patent #: 7,385,497; Independent Claim 1
DHS; S&T "Cell-All" initiative. Develop detection device to detect deadly chemicals". Stephen Dennis; PM: Contracts to Qualcomm, LG, Apple, and Samsung. Sensors will integrate with 261 million electronic devices (i.e. cell phones)	A monitoring device, comprising:	A communication device of at least one of a cell phone, a smart phone, a desktop, a handheld, a personal digital assistant (PDA), a laptop, or a computer terminal, comprising:	A communication device of at least one of a cell phone, a smart phone, a desktop, a handheld, a PDA, a laptop, or a computer terminal for monitoring products, interconnected to a product for communication therebetween, comprising:	A multi sensor detection and lock disabling system for monitoring products and for detecting chemical, biological, and radiological agents and compounds so that terrorist activity can be prevented, comprising:
The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video. The Snapdragon system on chip (SoC) was announced in Nov. 2006.	at least one central processing unit (CPU);	at least one of a central processing unit (CPU), a network processor, or a front end processor for communication between a host computer and other devices;	at least one of a central processing unit (CPU) for executing and carrying out the instructions of a computer program, a network processor which is specifically targeted at the networking application domain, or a front end processor for communication between a host computer and other devices;	a detector case including a front side, a rear side, a power source and a Central Processing Unit (cpu); *Note: Golden's Patents for the Detector Case (i.e. CMDC device; electronic device) ornamental design that antedates Apple's 1ˢᵗ Patent for the Smartphone (i.e. electronic device) ornamental design is illustrated in a chart included in this document*

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Qualcomm® Bluetooth® Low Energy Solutions Environmental Sensor Board Sensors: Accelerometer sensor, Temperature sensor, Pressure sensor, Magnetometer sensor, Humidity sensor, Gyro/angular sensor	at least one temperature sensor in communication with the at least one CPU for monitoring temperature;	X	X	X
Snapdragon sensor engine supports course motion classification, which determines standing, resting, walking, running, driving, or parking.	at least one motion sensor in communication with the at least one CPU;	X	X	X
Qualcomm TruPalette display tech is supported by Qualcomm Snapdragon processors	at least one viewing screen for monitoring in communication with the at least one CPU;	X	X	each detector including a sound alarm indicator, a readings panel, a light alarm indicator and a sensor
The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video	at least one global positioning system (GPS) connection in communication with the at least one CPU;	whereupon a signal sent to the receiver of at least one of... a cell phone detection device... from a satellite or a cell phone tower or... a GPS connection... causes a signal that includes at least one of location data or sensor data to be sent to the communication device...	at least one satellite connection, Bluetooth connection, WiFi connection, internet connection, radio frequency (RF) connection, cellular connection, broadband connection, long and short range radio frequency (RF) connection, or GPS connection;	an Internet connection, a GPS connection, and a power connection located on the rear side and which are interconnected with the cpu;

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Apple iPhone 8; Qualcomm Modem Model A1663; 802.11ac Wi Fi with MIMO; Bluetooth 5.0 wireless technology; NFC with reader mode.	at least one of an internet connection or a Wi-Fi connection in communication with the at least one CPU;	wherein at least one of a... WiFi connection, internet connection... capable of signal communication with... the communication device, the receiver of the communication device, or the central processing unit (CPU).	wherein the only type or types of communication with the transmitter and the receiver of the communication device and transceivers of the products is a type or types selected from the group consisting of satellite, Bluetooth, WiFi...	X
Apple iPhone 7; Qualcomm Modem Model A1660; 802.11ac Wi Fi with MIMO; Bluetooth 4.2 wireless cellular technology; NFC with reader mode.	at least one of a Bluetooth connection, a cellular connection, or a satellite connection in communication with the at least one CPU;	at least one of a satellite connection, Bluetooth connection, WiFi connection, internet connection, cellular connection, long and/or short range radio frequency (RF) connection, or GPS connection;	X	X
Qualcomm Technologies SafeSwitch is available through its Qualcomm Snapdragon processors. SafeSwitch technology - addresses mobile security threat with a kill switch solution designed to remotely disable the devices in the event they're lost or stolen - then re-enable when found.	at least one locking mechanism in communication with the at least one CPU for locking the communication device, the at least one locking mechanism configured to at least one of engage (lock) the communication device, disengage (unlock) the communication device, or disable (make unavailable) the communication device;	the communication device being equipped to receive signals from or send signals to engage (lock), disengage (unlock), or disable (make unavailable) locks;	X	an automatic/mechanical lock disabler interconnected to the cpu and which is mounted to a lock on a product for receiving transmission from the cpu to lock or disable the lock on the product to prevent access to the product by unauthorized, untrained and unequipped individuals; and

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Qualcomm Quick Charge: Qualcomm's Snapdragon SoCs is used in a number of popular smartphones and tablets, has its own fast-charging standard. Quick Charge is a technology found in Qualcomm SoCs, used in devices such as mobile phones, for managing power delivered over USB.	at least one power source comprising at least one of a battery, electrical connection, or wireless connection, to provide power to the communication device;	X	X	an Internet connection, a GPS connection, and a power connection located on the rear side and which are interconnected with the cpu;
Authenticating beyond secure fingerprint identification, a Snapdragon 835 Mobile Platform provides safety using Camera Security—a camera-based biometric solution for iris and facial recognition.	at least one biometric sensor in communication with the at least once CPU for providing biometric authentication to access the communication device;	the communication device being equipped with biometrics that incorporates at least one of a fingerprint recognition or a face recognition to at least one of gain access to the device or to prevent unauthorized use;	wherein the communication device is equipped with a biometric lock disabler that incorporates at least one of a fingerprint recognition, voice recognition, face recognition, hand geometry, retina scan, iris scan and signature such that the communication device that is at least one of the cell phone, the smart phone, the desktop, the handheld, the PDA, the laptop or the computer terminal is locked by the biometric lock disabler to prevent unauthorized use	X

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Synkera MikroKera Ultra: wireless, wearable, mobile, device detects and identify chemicals in the air using a "sample jet" and sends detection data to another phone or a computer Samsung Gear S2 3G Watch & Samsung Gear S Watch (Qualcomm Snapdragon 400 Processor); LG Watch Sport & LG G Watch R & LG Watch Urban (Qualcomm Snapdragon 400 Processor) for chem / bio / human heart rate detection and monitoring	at least one sensor for chemical, biological, or human detection in communication with the at least one CPU;	the communication device being at least a fixed, portable or mobile communication device, equipped with at least one wired or wireless sensor for the detection of humans;	the communication device is at least a fixed, portable or mobile communication device interconnected to a fixed, portable or mobile product, capable of wired or wireless communication therebetween…	a plurality of interchangeable detectors for detecting the chemical, biological and radiological agents and compounds and capable of being disposed within the detector case;
Synkera MikroKera Ultra: The device detects and identify chemicals in the air using a "sample jet" and sends detection data to another phone (e.g. Smartphone) or a computer "How does it work?" Shows indicator lights for the monitoring device; relayed over a cellular network to the monitoring center. WMD sensor development for the Cell-All Initiative: Qualcomm, NASA, and Rhevision Technology	one or more detectors in communication with the at least one CPU for detecting at least one of chemical, biological, radiological, or explosive agents;	at least one of a chemical sensor, a biological sensor, an explosive sensor, a human sensor, a contraband sensor, or a radiological sensor; that is wired or wireless, capable of being disposed within, on, upon or adjacent the communication device;	wherein the communication device receives a signal via any of one or more products listed in any of the plurality of product grouping categories;	a plurality of indicator lights located on the front side with each indicator light corresponding to and indicating the detection of one specific chemical, biological and radiological agent and compound;

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Qualcomm include NXP's near-field communication (NFC) solution in the Snapdragon processor platform that powers mobile devices (e.g. smartphones), wearables (e.g. smartwatches), and automobiles.	at least one radio-frequency near-field communication (NFC) connection in communication with the at least one CPU…	the communication device being capable of wireless near-field communication (NFC) which allows radio frequency (RF) data to be at least one of received or transferred between the communication device and at least one tag that is read by the communication device;	X	X
Qualcomm Technologies developed the QCA4020 tri-mode connectivity system-on-chip (SoC), the IoT industry's first commercially sampling connectivity solution that integrates three major radios in one low-power, cost-optimized chip. Connecting IoT devices like Refrigerators, TVs, security systems, thermostats, door locks. The Snapdragon 820A enables the driver attention-sensing cameras and autonomous controls to fingerprint-based door locks **Synkera MikroKera Ultra:** The device detects and identify chemicals in the air using a "sample jet" sends detection data to another phone	at least one of a transmitter or a transceiver in communication with the at least one CPU configured to send signals to monitor at least one of a door, a vehicle, or a building, send signals to lock or unlock doors, send signals to control components of a vehicle, send signals to control components of a building, or… detect at least one of a chemical biological, radiological, or explosive agent such that the communication device is capable of communicating, monitoring, detecting, and controlling.	a transmitter for transmitting signals and messages to at least one of a multi-sensor detection device, a cell phone detection device, or a locking device; a receiver for receiving signals, data or messages from at least one of a multi-sensor detection device, a cell phone detection device, or a locking device;	a transmitter for transmitting signals and messages to at least one of plurality product groups based on the categories of a multi-sensor detection device, a maritime cargo container, a cell phone detection device, or a locking device; a receiver for receiving signals, data or messages from at least one of plurality product groups based on the categories of a multi-sensor detection device, a maritime cargo container, a cell phone detection device, or a locking device;	whereupon detection of specific chemical, biological, or radiological agents or compounds by the detectors causes the lighting of the corresponding indicator light for visual confirmation of the detection and initiates signal transmission from the cpu to the automatic/mechanical lock disabler to lock or disable the lock of the product thereby preventing further contamination about the product and denying access to the product by unauthorized, untrained and unequipped individuals.

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Qualcomm Technologies developed the QCA4020 tri-mode connectivity system-on-chip (SoC), the IoT industry's first commercially sampling connectivity solution that integrates three major radios in one low-power, cost-optimized chip. Connecting IoT devices like Refrigerators, TVs, counter top appliances, security systems, thermostats, door locks.	X	X	whereupon the communication device, is interconnected to a product equipped to receive signals from or send signals to lock or unlock doors, activate or deactivate security systems, activate or deactivate multi-sensor detection systems, or to activate or deactivate cell phone detection systems;	X
Qualcomm's IoT include: Qualcomm® Snapdragon™ processors and LTE modems, Bluetooth, Wi-Fi, GNSS and NFC. Qualcomm Technologies RF solutions includes multimode and multiband RF transceivers. Qualcomm's Qualcomm RF360 Front End Solution, addresses cellular radio frequency band fragmentation and enables a single, global 4G LTE design for mobile devices.	X	X	wherein at least one satellite connection, Bluetooth connection, WiFi connection, internet connection, radio frequency (RF) connection, cellular connection, broadband connection, long and short range radio frequency (RF) connection is capable of signal communication with the transmitter and the receiver of the communication device and transceivers of the products;	X

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DOMESTIC CLAIM CHART

Enclosures:

DOMESTIC CLAIM CHART - QUALCOMM

QUALCOMM'S CLAIMED SMARTPHONE INVENTIONS

QUALCOMM'S INTERNET of THINGS (IoT)

HISTORY - 2007

Submitted by Complainant: Larry Golden

COMPLAINANT'S DOMESTIC INDUSTRY

CLAIM CHART

RESPONDENT: QUALCOMM

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
12. The communication device of [claim 11] wherein each communication device includes at least one of an internet connection, a GPS connection, a radio frequency (RF) connection, or a central processing unit (cpu).	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video
16. The communication device of [claim 11] wherein the communication device can be adapted or incorporated with cell phone towers and satellites for use with satellite communication and/or a cell tower, wi-fi, wi-max, broadband, GPS, navigation, radio frequency (RF) chips, radio frequency (RF) sensors, radio frequency (RF) transceivers, and radio frequencies for short and long range transmissions interconnected to the central processing unit (cpu).	NFC **Wireless Networking Technology Industry**	NFC chips might also be widely used in the Internet of Things. Qualcomm recently announced that it will include NXP's near-field communication (NFC) solution in the Snapdragon processor platform that powers mobile devices (e.g. smartphones), wearables (e.g. smartwatches), and automobiles
21. The communication device of [claim 11] wherein the communication device includes a power connection that is interconnected to the central processing unit (cpu) and power source can be battery, electrical, or solar.	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
22. The communication device of [claim 11] wherein the communication device is designed to be equipped with applications for the locking, disabling a lock, enabling a lock, and unlocking the locks of, but not limited to, containers, vehicles, houses and businesses, using a smart phone, cell phone, PDA, laptop or desktop.	Home and Community **Wireless Networking Technology Industry**	Every time you call, navigate, download, store something or talk, you've got the power of Qualcomm technology to thank. Also the advancements for your car, home and community are made possible by the mobile hardware, software and standards we pioneered. Qualcomm invented many of the technologies that the world's leading networks and devices run on—connecting new industries, services and experiences that are changing everything.
22. The communication device of [claim 11] wherein the communication device is designed to be equipped with applications for the locking, disabling a lock, enabling a lock, and unlocking the locks of, but not limited to, containers, vehicles, houses and businesses, using a smart phone, cell phone, PDA, laptop or desktop.	Disabling Lock **Locking Industry**	Qualcomm Technologies announced SafeSwitch in September of 2014. SafeSwitch is available to customers through its Qualcomm Snapdragon 810 processors. SafeSwitch technology - addresses mobile security threat with a kill switch solution is designed to allow device owners to remotely disable their devices in the event that they're lost or stolen - and then re-enable them in the event they're found. This helps to protect sensitive, valuable personal data and to deter device theft.
30. The communication device of [claim 11] wherein the communication device is designed to be used with or without biometrics for authentication and identification, with at least one of a fingerprint recognition, voice recognition, face recognition, hand geometry, retina scan, iris scan, heart rate, pulse or signature, thereby allowing access to the product by authorized, trained, and equipped individuals and preventing access to the product by unauthorized, untrained, and unequipped individuals.	Biometrics **Biometrics Industry**	Authenticating the user and the device. Beyond secure fingerprint identification, a Snapdragon 835 Mobile Platform provides a user with an extra level of safety using Camera Security—a camera-based biometric solution for iris and facial recognition engineered to help enhance mobile device security

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
30. The communication device of [claim 11] wherein the communication device is designed to be used with or without biometrics for authentication and identification, with at least one of a fingerprint recognition, voice recognition, face recognition, hand geometry, retina scan, iris scan, heart rate, pulse or signature, thereby allowing access to the product by authorized, trained, and equipped individuals and preventing access to the product by unauthorized, untrained, and unequipped individuals.	Biometrics **Biometrics Industry**	Mobile transactions are safest when they are protected by a combination of user and device authentication methods. This helps data remain secure from the moment a user logs into their device. A Snapdragon 835 Mobile Platform contains the Qualcomm Haven™ security platform—a combination of hardware, software and biometrics technologies that help to make online banking and payments more secure than ever.
39. The lock disabler system of [claim 33] wherein the automatic/mechanical lock disabler detection device has a power connection which is interconnected to the central processing unit (cpu) and includes a power source of battery, electrical or solar.	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video
41. The lock disabler system of [claim 33] wherein the automatic/mechanical lock disabler detection device includes at least one of; a Blue tooth connection, a Wi-Fi connection, a short and long range radio frequency connection, an Internet connection, a Cellular connection, a Satellite connection, all of which are capable of being interconnected to a central processing unit (cpu) of the communication device.	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
55. The multi-sensor detection system of [claim 33] wherein each communication device includes at least one of an internet connection, a GPS connection, a radio frequency (RF) connection, or a central processing unit (cpu).	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video
78. The built-in, embedded multi sensor detection system of [claim 74] wherein the product includes at least one of a built-in, embedded internet component, a global positioning (GPS) component, a navigation component, a tracking component, a cellular component, a satellite component, a short and long range radio frequency component, radio frequency (RF) sensor, radio frequency (RF) transceiver, Wi-Fi, antenna, Bluetooth, or interface/gateway component.	Cellular and Wireless Modem: Smartwatches **Electronic Device Industry**	Qualcomm supplied the LTE modem in the Apple Watch Series 3. TechInsights found the Qualcomm MDM9635M, a Snapdragon X7 LTE modem in the 42mm sport band model A1861 with GPS + cellular it opened up. The modem was mated in a package-on-package with a Samsung K4P1G324EH DRAM in the watch. Among other wireless chips, TechInsights said the watch contains a Qualcomm PMD9645 PMIC and a WTR3925 RF transceiver. Apple and Qualcomm are embroiled in a handful of patent infringement disputes including investigations at the U.S. ITC, particularly around baseband modems. Apple continues to use the Qualcomm parts in watches despite threats of injunctions. Apple decided to discontinue paying Qualcomm royalties while court cases are in progress.

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
78. The built-in, embedded multi sensor detection system of [claim 74] wherein the product includes at least one of a built-in, embedded internet component, a global positioning (GPS) component, a navigation component, a tracking component, a cellular component, a satellite component, a short and long range radio frequency component, radio frequency (RF) sensor, radio frequency (RF) transceiver, Wi-Fi, antenna, Bluetooth, or interface/gateway component.	Cellular and Wireless Modem: Smartphone **Mobile Device Industry**	The iPhone X A1865 uses the Qualcomm MDM9655 Snapdragon X16 LTE modem. iPhone 8; Qualcomm Modem Model A1663; plus 802.11ac Wi Fi with MIMO; Bluetooth 5.0 wireless technology; NFC with reader mode. iPhone 8 Plus; Qualcomm Modem Model A1664; plus 802.11ac Wi Fi with MIMO; Bluetooth 5.0 wireless technology; NFC with reader mode. iPhone 7; Qualcomm Modem Model A1660; plus 802.11ac Wi Fi with MIMO; Bluetooth 4.2 wireless technology; NFC with reader mode. iPhone 7 Plus; Qualcomm Modem Model A1661; plus 802.11ac Wi Fi with MIMO; Bluetooth 4.2 wireless technology; NFC with reader mode. The Qualcomm MDM9625M is a modem LTE chipset found in the Apple MG9M2CL/A iPhone 6 Plus and iPhone 6.
78. The built-in, embedded multi sensor detection system of [claim 74] wherein the product includes at least one of a built-in, embedded internet component, a global positioning (GPS) component, a navigation component, a tracking component, a cellular component, a satellite component, a short and long range radio frequency component, radio frequency (RF) sensor, radio frequency (RF) transceiver, Wi-Fi, antenna, Bluetooth, or interface/gateway component.	Wi-Fi **Wireless Networking Technology Industry**	With all the devices connecting to all the things, we knew we had to help ease overload. So we were the first to announce end-to-end commercial support for the next-generation of Wi-Fi. What does that mean? It translates into faster delivery and longer battery life for Wi-Fi devices—whether you're at home or on the go.

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
79. The built-in, embedded multi sensor detection system of [claim 74] wherein the product includes at least one of a built-in, embedded wireless and/or wired communication connection capable of sending signals and messages to a product; receiving signals and messages from a product; interconnected to at least one of a cell phone, a smart phone, a PDA, a handheld, a laptop, a desktop, a workstation, monitoring site or another product comprises a built-in, embedded wireless and/or wired communication connection.	Modems **Wireless Networking Technology Industry**	Qualcomm quote: "Some say the modem is the most important part of your smartphone. We couldn't agree more. With our wireless modem inside your smartphone, you've got years of engineering keeping you connected to your great big world. And isn't that why you bought that device in the first place?"
79. The built-in, embedded multi sensor detection system of [claim 74] wherein the product includes at least one of a built-in, embedded wireless and/or wired communication connection capable of sending signals and messages to a product; receiving signals and messages from a product; interconnected to at least one of a cell phone, a smart phone, a PDA, a handheld, a laptop, a desktop, a workstation, monitoring site or another product comprises a built-in, embedded wireless and/or wired communication connection.	LTE **Wireless Networking Technology Industry**	Everyone promises smarter/better/faster, but with LTE, we actually delivered. We invented the wireless standards and fundamental technologies that mobile operators rely on to meet the explosive demand in mobile data traffic. And that means you can catch up on the latest sports clips without waiting for the network to keep pace.
104. The multi-sensor detection system of [claim 103] wherein each cell phone detector case includes an internet connection, a GPS connection, a radio frequency (RF) connection, a recharging cradle or seat, a front side, a top, a bottom, a pair of opposed sides and a central processing unit (cpu).	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
108. The multi-sensor detection system of [claim 103] wherein the cell phone, the smart phone, and the cell phone detector case can be adapted or incorporated with cell phone towers and satellites for use with at least one of satellite communication, a cell tower, wi-fi, wi-max, broadband, GPS, navigation, radio frequency (RF) chips, radio frequency (RF) sensors, radio frequency (RF) transceivers, and radio frequencies for short and long range transmissions interconnected to a central processing unit (cpu).	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video
113. The multi-sensor detection system of [claim 103] wherein the cell phone, the smart phone, and the cell phone detector case includes a power connection that is interconnected to a central processing unit (cpu), and wherein a power source can be battery, electrical, or solar.	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video
126. The multi-sensor detection system of [claim 125] wherein each communication device includes at least one of an internet connection, a GPS connection, a radio frequency (RF) connection, or a central processing unit (cpu).	Qualcomm Snapdragon Processor: Smartwatches **Industry for Processors** **Electronic Device Industry**	Samsung Gear S2 3G Watch (Qualcomm Snapdragon 400 Processor); Samsung Gear S Watch (Qualcomm Snapdragon 400 Processor); LG Watch Sport (Qualcomm Snapdragon Wear 2100 Processor); LG Watch Style (Qualcomm Snapdragon Wear 2100 Processor); LG G Watch R (Qualcomm Snapdragon 400 Processor); LG Watch Urban (Qualcomm Snapdragon 400 Processor).

Complainant RE43,990 Patent Dependent Claims	Qualcomm's Technological Capability and Industry	Qualcomm's Technological Capability (Description)
126. The multi-sensor detection system of [claim 125] wherein each communication device includes at least one of an internet connection, a GPS connection, a radio frequency (RF) connection, or a central processing unit (cpu).	Qualcomm Snapdragon Processor: Smartphone **Industry for Processors** **Mobile Device Industry**	Samsung Galaxy S8 (Qualcomm Snapdragon 835 Processor); Samsung Galaxy Note 8 (Qualcomm Snapdragon 835 Processor); Samsung Galaxy S7 (Qualcomm Snapdragon 820 Processor); Samsung Galaxy S5 (Qualcomm Snapdragon 801 Processor); Samsung Galaxy S4 (Qualcomm Snapdragon 600 Processor); LG V30 (Qualcomm Snapdragon 835 Processor); LG G5 (Qualcomm Snapdragon 820 Processor); LG G4 (Qualcomm Snapdragon 808 Processor); LG G3 (Qualcomm Snapdragon 801 Processor); LG Pro 2 (Qualcomm Snapdragon 800 Processor).
132. The multi-sensor detection system of [claim 125] wherein the internal or external remote/electrical lock disabler includes at least one of: a Blue tooth connection, a Wi-Fi connection, a short and long range radio frequency connection, an Internet connection, a Cellular connection, a Satellite connection, all of which are interconnected to the central processing unit (cpu).	Central Processing Unit (CPU) **Industry for Processors**	Snapdragon is a suite of system on a chip (SoC) semiconductor products designed and marketed by Qualcomm for mobile devices. The Snapdragon system on chip (SoC) was announced in November 2006. The Snapdragon central processing unit (CPU) uses a single SoC that may include multiple CPU cores, a wireless modem, and other software and hardware to support a smartphone's global positioning system (GPS), camera, gesture recognition and video
134. The multi-sensor detection system of [claim 125] wherein a communication device, that of a cell phone, smart phone or handheld; capable of sending signals to a vehicle's operating equipment systems of at least one of, but not limited to, an ignition for starting and stopping, a lock for unlocking and locking, a horn for sounding; capable of receiving data and diagnostic information of the vehicle's operating equipment systems.	Car **Automobile Industry**	Every time you navigate you've got the power of Qualcomm technology to thank. All the advancements coming to your car, home and community are made possible by the mobile hardware, software and standards we pioneered. Qualcomm invented many of the technologies that the world's leading networks and devices run on.

12/21/2017

List of Qualcomm Snapdragon systems-on-chip - Wikipedia

Model number	Fab	CPU ISA	CPU	CPU cache	GPU	Memory technology	Wireless radio technologies	Sampling availability	Devices using it
MSM7225[1]			Up to 528 MHz ARM11	16K+16K L1 no L2	Software rendered 2D support	Single-Channel 166MHz LPDDR (1.33 GB/s)	GSM (GPRS/EDGE), UMTS (HSPA)	2007	**List** HTC Tattoo, Wildfire; **Huawei** U8110, IDEOS X2 U8500/Evolución UM840; **Vodafone** 858 Smart
MSM7625[1]							GSM (GPRS/EDGE) CDMA (1× Rev. A, 1×EV-DO Rev. A) UMTS (HSPA)		**List** HTC Wildfire A315c, Wildfire 6225;[2] **Huawei** IDEOS C8150/U8150, M835, Ascend M860.
MSM7227[1]	65 nm	ARMv6	Up to 800 MHz ARM11	16K+16K L1 256K L2	Adreno 200 226MHz	Single-Channel 166MHz LPDDR (1.33 GB/s)	GSM (GPRS/EDGE), UMTS (HSPA)	2008	**List** 600 MHz **Alcatel** OT-990; **Coolpad** W706, **Garmin & Asus** A10, M10; **Gigabyte** GSmart G1305 Boston; **HTC** Aria, Gratia, Legend, Wildfire S; **Huawei** Ideos X3, Pocket WiFi S II (S41HW), Sonic (U8650); **LG** GT540 Optimus, Optimus Chat (L-04C), Optimus Chic, Optimus Me, Optimus One (GSM); **Micromax** A70; **Moxi** MT; **Nexian** A890 Journey; **OlivePad** VT-100; **Optimus** Boston; **Palm** Pixi (GSM); **Samsung** Galaxy Europa (i5500 Galaxy 5), Galaxy Fit, Galaxy Mini, Galaxy 551; **Sony Ericsson** Xperia X10 Mini, Xperia X10 Mini Pro, M1i Aspen, Xperia X8; **T-Mobile** myTouch 3G Slide; **WellCom** A88; **ViewSonic** ViewPad 7; **ZTE** Blade, Racer, Merit (990G) 800 MHz **Coolpad** 7260; **Huawei** Smart Bar (S42HW); **HTC** ChaCha, Salsa; **LG** Optimus Hub, Optimus Net (P699); **Motorola** XT-502; **Odys** Space; **Samsung** Galaxy Ace, Galaxy Gio; **ZTE** Blade S, N762, Skate
MSM7627[1]							GSM (GPRS/EDGE) CDMA (1× Rev. A, 1×EV-DO Rev. A) UMTS (HSPA)		**List** **BlackBerry** Curve (8530); **Coolpad** 5820; **Huawei** Evolución 2 CM980, Ascend II (M865C); **Kyocera** Zio; **LG** Optimus S, Optimus Q (L45C), Optimus V, Optimus Zip (L75C), VS740; **Motorola** Devour, ES400; **Ouku** Horizon P801W; **Palm** Pixi Plus; **Samsung** Galaxy Prevail, Galaxy Precedent (SCH-M828C),[3] Galaxy Y (SCH-i509) (CDMA), **Unimax** MaxBravo (U670C); **ZTE** Score x500
MSM7225A	45 nm	ARMv7		32K+32K L1 256K L2	Adreno 200 245MHz	Single-Channel 200MHz LPDDR (1.6 GB/s)	GSM (GPRS, EDGE), W-CDMA/UMTS (HSDPA, HSUPA), MBMS	Q4 2011	**List**
MSM7625A			Up to 800 MHz Cortex-A5				GSM (GPRS, EDGE) W-CDMA/UMTS (HSDPA, HSUPA), MBMS, CDMA2000 (1×RTT, 1×EV-DO Rel.0/Rev.A/Rev.B, 1×EV-DO MC Rev.A)		**List**
MSM7227A			Up to 1 GHz Cortex-A5				GSM (GPRS, EDGE), W-CDMA/UMTS (HSDPA, HSUPA), MBMS		**List**
MSM7627A							GSM (GPRS, EDGE) W-CDMA/UMTS (HSDPA, HSUPA), MBMS, CDMA2000 (1×RTT, 1×EV-DO Rel.0/Rev.A/Rev.B,		**List**

YEAR OF DHS CONTRACT (handwritten annotation)

12/21/2017   List of Qualcomm Snapdragon systems-on-chip - Wikipedia

Model number	Fab	CPU				GPU		DSP		Memory technology			Wireless		Sampling availability	Devices using it
		ISA	μarch	Cores	Freq. (GHz)	μarch	Freq. (MHz)	μarch	Freq. (MHz)	Type	Bus width (bit)	Bandwidth (GB/s)	Cellular	WLAN; PAN; GNSS		
MSM8998 (835)	10 nm FinFET LPE (Samsung)	ARMv8-A	Kryo 280	4 + 4 Octa-core (2.45GHz+1.9GHz A73 custom)	2.45 + 1.9	Adreno 540	710 MHz (567 GFLOPS)	Hexagon 682	200 ?	LPDDR4X	Dual-channel 32-bit (64-bit)	1866 MHz (29.8 GB/s)	X16 LTE (download: Cat 16, up to 1000 Mbit/s; upload: Cat 13, up to 150 Mbit/s)	802.11a/b/g/n/ac Wave 2(MU-MIMO)/ad; Bluetooth 5; GPS, GLONASS, Beidou, Galileo, QZSS, SBAS	Q2 2017[288]	List • Samsung Galaxy S8 (USA/China) • Samsung Galaxy S8+ (USA/China) • Samsung Galaxy S8 Active (AT&T USA) • Samsung Galaxy Note 8 (USA/China) • Sharp Aquos R • Sony Xperia XZ Premium • Sony Xperia XZ1 • Sony Xperia XZ1 Compact • LG V30 • LG V30+ • Google Pixel 2 • Google Pixel 2 XL • Xiaomi Mi 6[289] • Xiaomi Mi MIX 2 • Essential PH-1 • Razer Phone • HTC U11 • HTC U11+ • OnePlus 5 • OnePlus 5T • Motorola Moto Z2 Force • Archos Diamond Omega • Nokia 8[290] • Asus Zenfone 4 Pro (Z01GD)

(Handwritten annotation: "10 YEARS LATER")

QUALCOMM'S CLAIMED SMARTPHONE INVENTIONS

Qualcoʌʌʌ

☰

QUALCOʌʌʌ | Invention ⌄   Your Smartphone

𝒪

We're the reason you love your smartphone.

Nothing is as indispensable to our everyday lives as the smartphone. And as a company of inventors, we're always looking ahead to the next great innovation. From keeping your home secure to sharing your story with the world, from connecting with family to discovering the community around you, we know you love your smartphone. And all those amazing things you love about your phone were made possible by many Qualcomm inventions.

Battery Life

Who wants a dead phone? Not you. Get more out of your device with our inventions that reduce overall mobile device power usage—so powering off is your choice, not your smartphone's. And with our Qualcomm® Quick Charge™ technology from Qualcomm Technologies, Inc., devices charge uber fast, so you can spend even more time snapping selfies with your besties.

Security

Passcodes are so yesterday. Now that your device is your mobile wallet, you need more than a four-digit passcode. That's why we developed tools like secure 3D fingerprint authentication so that only you can access your data. And advanced encryption that securely transmits your data file. Our security platform even protects your device from malicious attacks. Hey, we've got your back.

Functionality

We can all use a little help from time to time, and with your smartphone, you're never on your own. It can find the nearest coffee shop, send a text with your voice (instead of your thumbs) and answer some of life's deepest questions—all thanks to our voice recognition technology. It's kind of like having a super smart friend in the palm of your hand.

Next up: leading the world to 5G.

From battery life to security to voice recognition, modern phones run on a whole lot of Qualcomm.

Your smartphone does more than snap pretty pictures. It keeps your data secure, responds to the sound of your voice, and knows that your fingerprint is the key to unlocking everything that matters most to you. And as our devices run larger and larger files and apps, we've developed battery technologies that charge your device faster and smarter without compromising battery life.

MODEM

Modems

Some say the modem is the most important part of your smartphone. We couldn't agree more. With our wireless modem inside your smartphone, you've got years of engineering keeping you connected to your great big world. And isn't that why you bought that device in the first place?

We connected the smartphone to the internet and that changed everything.

Every time you snap, shop, navigate, stream, download, store something or even just talk, you've got the power of Qualcomm technology to thank. Oh, and all those advancements that are coming to your car, home and community? They're made possible by the mobile hardware, software and standards we pioneered. From 3G to LTE to Wi-Fi and beyond, Qualcomm invented many of the technologies that the world's leading networks and devices run on—connecting new industries, services and experiences that are changing everything.
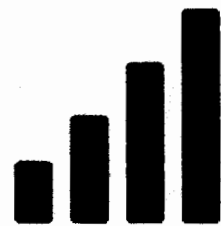
LTE

Everyone promises smarter/better/faster, but with LTE, we actually delivered. We invented the wireless standards and fundamental technologies that mobile operators rely on to meet the explosive demand in mobile data traffic. And that means you can catch up on the latest sports clips without waiting for the network to keep pace.

Wi-Fi

With all the devices connecting to all the things, we knew we had to help ease overload. So we were the first to announce end-to-end commercial support for the next-generation of Wi-Fi. What does that mean? It translates into faster delivery and longer battery life for Wi-Fi devices—whether you're at home or on the go.

Powerful Camera

Our image stabilization invention means no more blurry photos. And just so you can find every photo of Fido when you search your camera roll for "dog," we developed photo recognition technology that uses machine learning to recognize and sort all those images (and we know you have a lot of them).

Enhanced Video Streaming

There's a reason you can't keep your eyes off your phone: our algorithms that reduce packet loss and intelligently compress images. Which is a techy way of saying, "Wow, those videos are amazing."

Location Services

Now you can no longer claim you're late because you got lost. We optimized the reliability and accuracy of your location by enabling the device to receive signals from multiple satellites. Which means we can keep you on track even if a satellite signal can't reach you.

It's impossible to imagine a smartphone without features we made possible.

All those things you love doing with your phone, we had a lot to do with that. Like backlit selfies that showcase our image stabilization technology. And finding the hottest restaurant on a crowded street even if you have no sense of direction—that's the pinpoint accuracy of our position location innovations. And those gorgeous graphics, lightning-fast streaming and immersive 3D experiences? All thanks to our video streaming inventions. And all built with you in mind. In fact, our inventions are behind many of the most crucial features you use on a daily basis.

QUALCOMM'S INTERNET OF THINGS (IoT)

≡   Qualcomm   ⌕

Qualcomm Technologies Announces Enhancements to the Qualcomm Network with New IoT Connectivity Platform and Expanded Wi-Fi SON Features

New platform unifies functionality through virtually seamless connectivity and delivers simplicity of use across devices and technologies

JAN 3, 2017   LAS VEGAS

Qualcomm products mentioned within this press release are offered by Qualcomm Technologies, Inc. and/or its subsidiaries.

Qualcomm Technologies, Inc., a subsidiary of Qualcomm Incorporated (NASDAQ: QCOM), today announced two new critically important elements of the Qualcomm® Network designed to deliver simple, consistent and seamless connected experiences. As network complexity and expectations skyrocket at the hands of insat. consumer demand, Qualcomm Technologies is introducing a suite of features, for deployment across IoT

devices, IoT hubs, and network gateways, that centralize and manage the complex and diverse connectivity technologies and ecosystems - the Qualcomm® Network IoT Connectivity platform. Additionally, Qualcomm Technologies is further broadening the capabilities of its award winning Qualcomm® Wi-Fi Self Organizing Network (SON) solution to help ensure the best managed network possible.

"The Qualcomm Network continues to redefine connected experiences by making connectivity simple, high quality and consistent across devices and technologies," said Gopi Sirineni, vice president, product management, Qualcomm Technologies, Inc. " IoT Connectivity platform and our expanded Wi-Fi SON capabilities together are designed to deliver on that promise by directly addressing the most fundamental connectivity challenges of IoT while ensuring a broad delivery of our innovations across wired and wireless networks."

Qualcomm Network IoT Connectivity Platform

The growth of IoT services and smart home devices has, until now, created islands of products rendered incompatible by conflicting connectivity technologies, communication protocols, and software frameworks. Building upon the success of Qualcomm Technologies' device-focused IoT solutions, such as the QCA401x and QCA4531, the Qualcomm Network IoT Connectivity platform is designed to help ensure, for the first time, compatible and simultaneous use of Wi-Fi, Bluetooth, CSRmesh™ connectivity, and 802.15.4-based technologies across a network. The Qualcomm Network IoT Connectivity platform also supports previously announced communication protocols, cloud services and software frameworks, allowing it to act as a universal translator. By connecting previously disparate product portfolios and ecosystems, the Qualcomm Network IoT Connectivity platform significantly minimizes complexity and eases fragmentation challenges for manufacturers, developers and consumers.

Qualcomm Network Wi-Fi SON Feature Expansion

Since its introduction a year ago, the Qualcomm Wi-Fi SON suite of features has spurred the disruptive tre toward distributed networking systems. Distributed networks deliver corner-to-corner Wi-Fi, automated

management with simple onboarding, and a host of other unique features. Every product to date employing a distributed networking architecture is based upon the Qualcomm Network solutions, including networking products announced at CES 2017.

With distributed networks seeing significant product traction, and the value Wi-Fi SON brings to networks recognized, Qualcomm Technologies is today announcing the expansion of the Wi-Fi SON capabilities to include:

- Support for both wired and wireline-based networks. This update allows network installations dependent on PLC, a previously announced upgrade, and/or Ethernet, to leverage the same innovative features, regardless of the network medium, that currently define the Wi-Fi implementations of SON.

- Expanded support for multi-hop network topologies. While a star topology is ideal for a majority of homes, there are many (multi-level, thick structures) where a multi-hop topology is more beneficial. Multi-hop topologies are the prototypical mesh-style configurations, and the addition of this option to Wi-Fi SON is designed to ensure a wider potential range of successful Wi-Fi SON implementations.

- Expansion of supported architectures to include MIPS-based systems.

Both the Qualcomm Network IoT Connectivity platform and expanded Qualcomm Wi-Fi SON features are available now as integrated offerings for Qualcomm Technologies Wi-Fi solutions for network infrastructure devices like network routers and gateways, with the Qualcomm Network IoT Connectivity Platform also available via our Qualcomm Technologies IoT device and hub solutions portfolio.

To get an up-close look at how these Qualcomm Network innovations are delivering simple, seamless networks that just work, please visit the Qualcomm booth at the Consumer Electronics Show, located in the Central H~'' booth #10948.

About Qualcomm

Qualcomm's technologies powered the smartphone revolution and connected billions of people. We pioneered 3G and 4G – and now, we are leading the way to 5G and a new era of intelligent, connected devices. Our products are revolutionizing industries including automotive, computing, IoT and healthcare, and are allowing millions of devices to connect with each other in ways never before imagined. Qualcomm Incorporated includes our licensing business, QTL, and the vast majority of our patent portfolio. Qualcomm Technologies, Inc., a subsidiary of Qualcomm Incorporated, operates, along with its subsidiaries, all of our engineering, research and development functions, and all of our products and services businesses, including our semiconductor business, QCT, and our mobile, automotive, computing, IOT and healthcare businesses. To learn more, visit Qualcomm's website, blog, Twitter and Facebook pages.

CES

Qualcomm is a trademark of Qualcomm Incorporated, registered in the United States and other countries.

CSRmesh is a trademark of Qualcomm Technologies International, Ltd., registered in the United States and other countries.

Qualcomm Network features, Qualcomm Network IoT Connectivity platform, and Qualcomm Wi-Fi SON features are products of Qualcomm Technologies, Inc.

CSRmesh is a product of Qualcomm Technologies International, Ltd.

Qualcomm Contacts

Pete Lancia

The Internet of Everything

How the **Internet of Everything** Will Change the World...for the Better

White Paper at:
http://www.cisco.com/web/about/ac79/docs/innov/IoE_Economy.pdf

14.4 Trillion Dollars by 2022

A good way to go beyond the "naming" confusion:
(IoT, M2M, Cyber-Physical Systems, Intelligent Systems, Industrial Internet, Connected Devices, etc., etc.)

Options within Settings

●●○○○ Verizon LTE   9:35 AM   ⤴ ⬛

Settings

- Wi-Fi is if the product connected to the Internet settings

- Bluetooth is a way to send pictures or videos, through an Internet connection and allows you to connect with other devices

- Personal hotspot allows you to use the Internet from cellular data. This feature uses additional data

Airplane Mode

Wi-Fi   Not Connected

Bluetooth   On

Cellular

Personal Hotspot   Off

Notifications

Control Center

Do Not Disturb

General

Collaborative Ad Hoc Networks
Defense Applications (see Persistent Systems)

UAVs

Manned Aircraft

Video Cameras

SATCOM

Mobile Devices

The Internet

Unmanned Ground
Robots

Biometric Scanners

Radio Over IP

Sensor Network
Gateways

PERSISTENT SYSTEMS
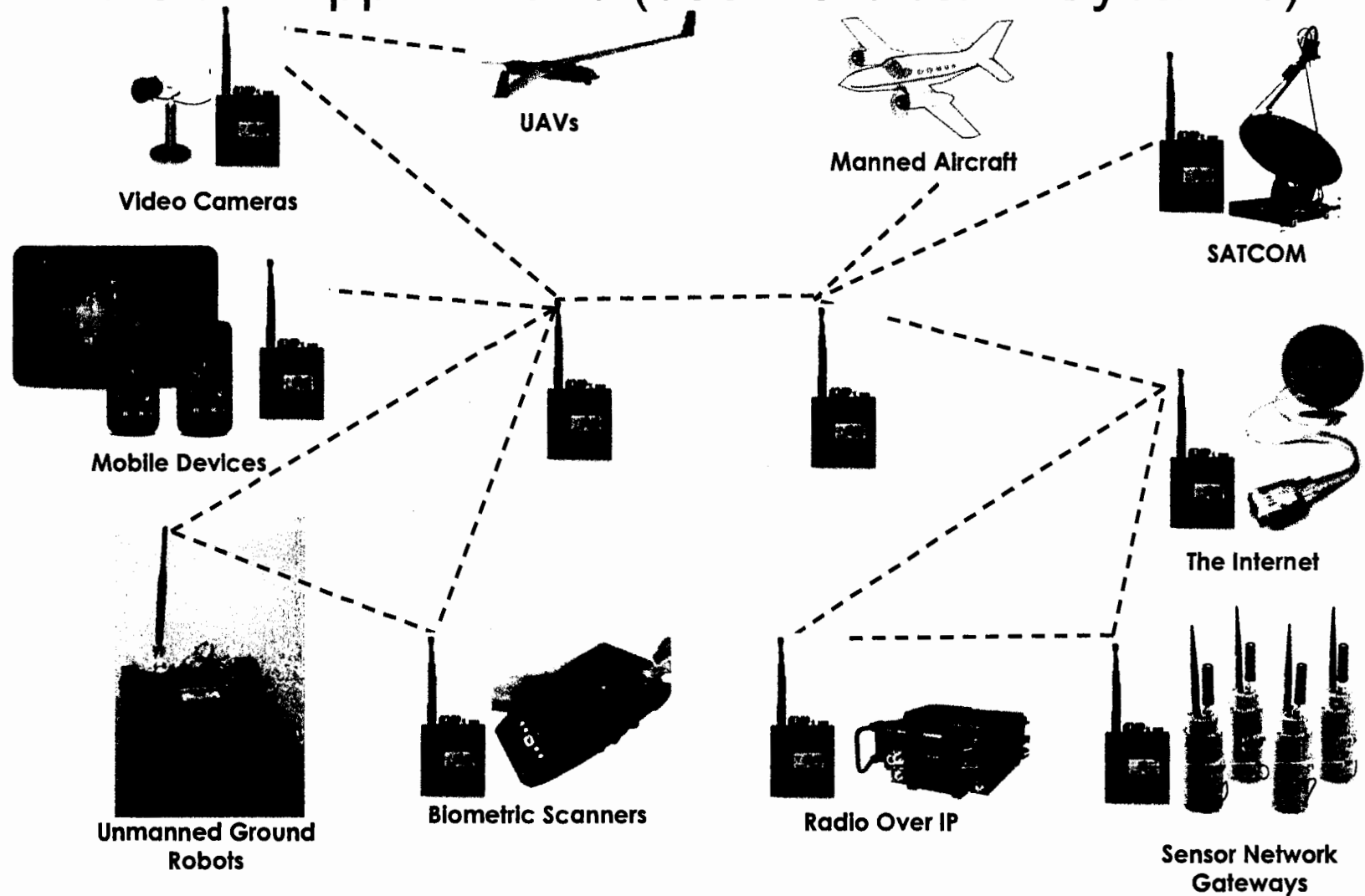
A Broad Set of Applications

Energy Saving (I2E)

Defense

Predictive maintenance

Enable New Knowledge
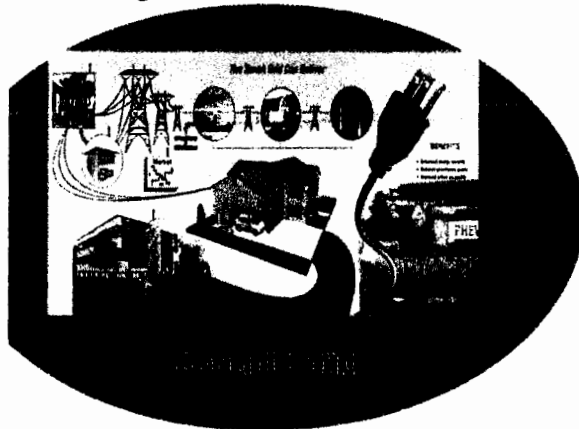
Intelligent Buildings
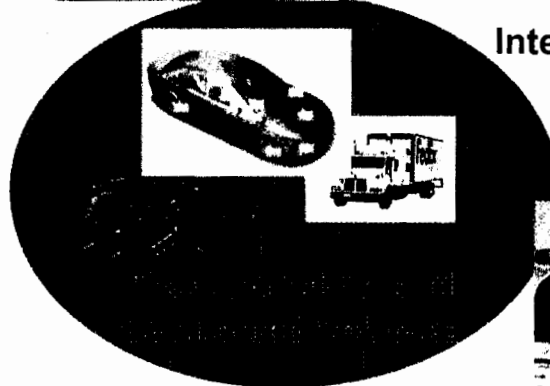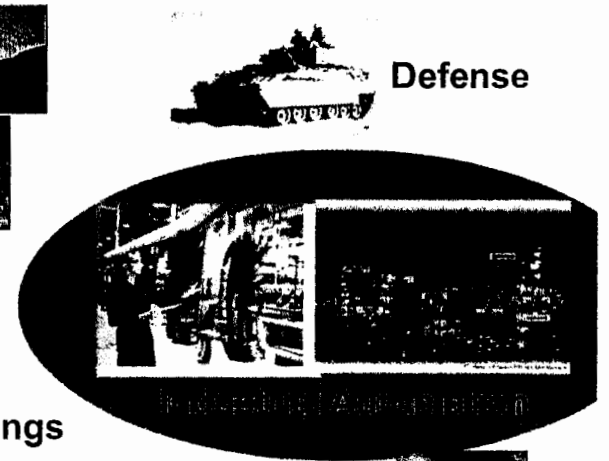
Enhance Safety & Security

Agriculture

Healthcare
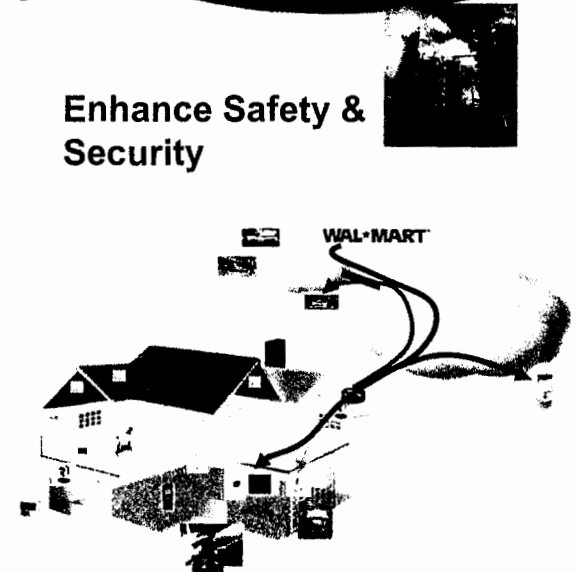
Smart Home
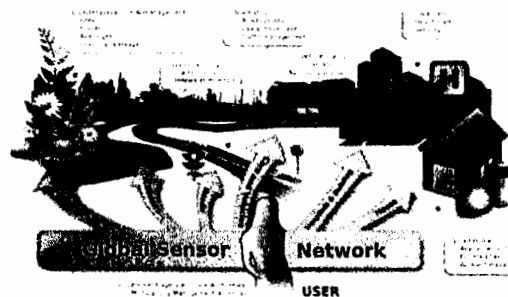
Smart City

Application Example over the "IoT Computer": Streetline Parking Automation

Data Center/Cloud
Hosting IoT analytics

Core
IP/MPLS, Security, QoS, Multicast, Network Services, Mobile Packet Core

Multi-Service Edge
3G/4G/LTE/WiFi/802.11p Wired

Embedded Systems and Sensors
Low power & bandwidth, smart things, vehicles, machines

Millions

STREETLINE
Connecting the Real World

Network Management   Applications

IP/MPLS Core

Distributed Intelligence: FOG Computing

Smart Things Network
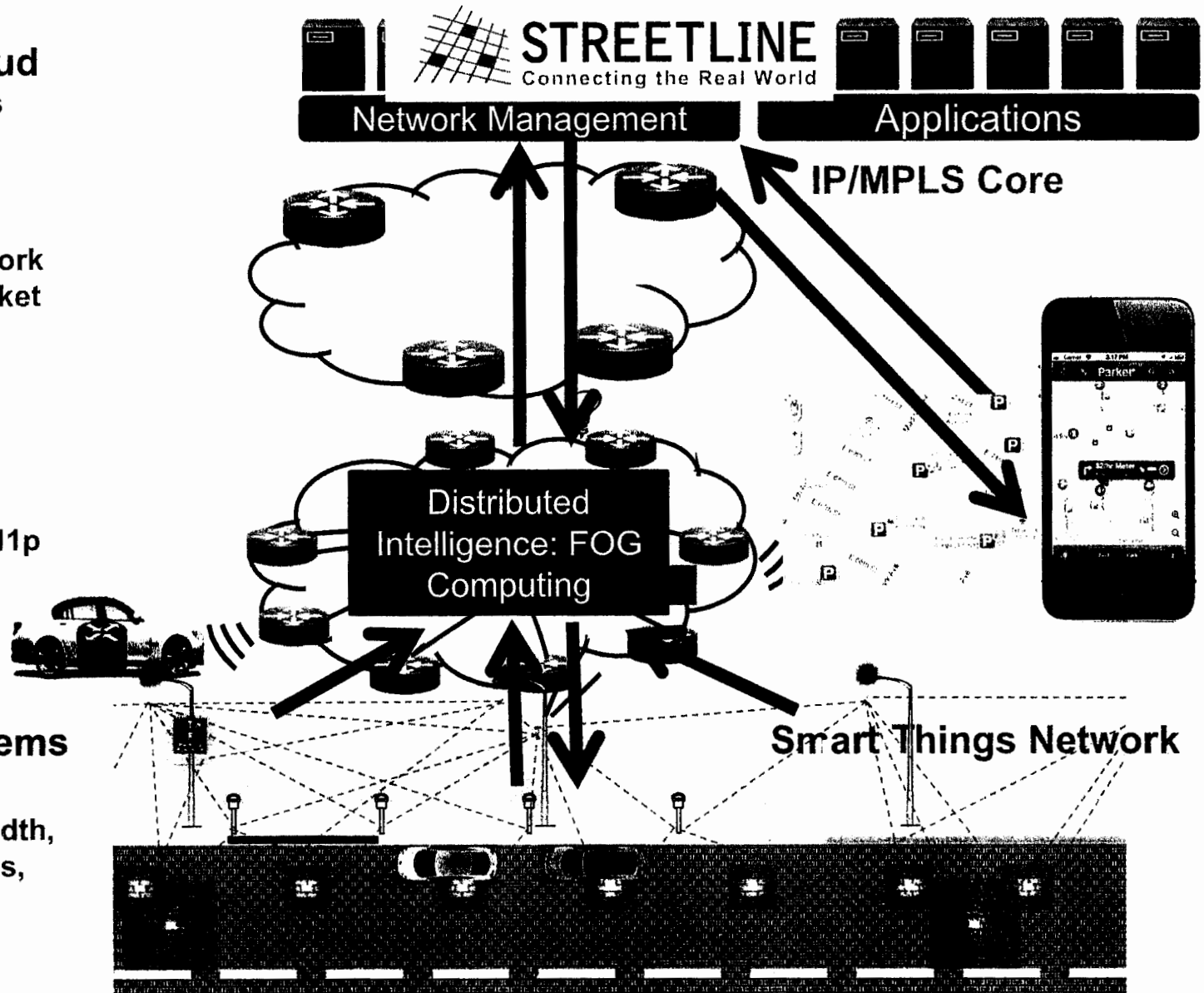
Connecting Cortex-M Processors to the Cloud

ARM®SENSINODE

IoT Technology

NanoService Client

NanoMesh

Things

Internet

NanoService Platform

cellular

NanoService Edge

802.15.4/WiFi   cable/cellular

Cloud Services and
Platforms

gateways

Bluetooth   cellular

smartphones

ARM™MBED™

IoT Development Platform

THE ARCHITECTURE FOR THE DIGITAL WORLD   **ARM**™
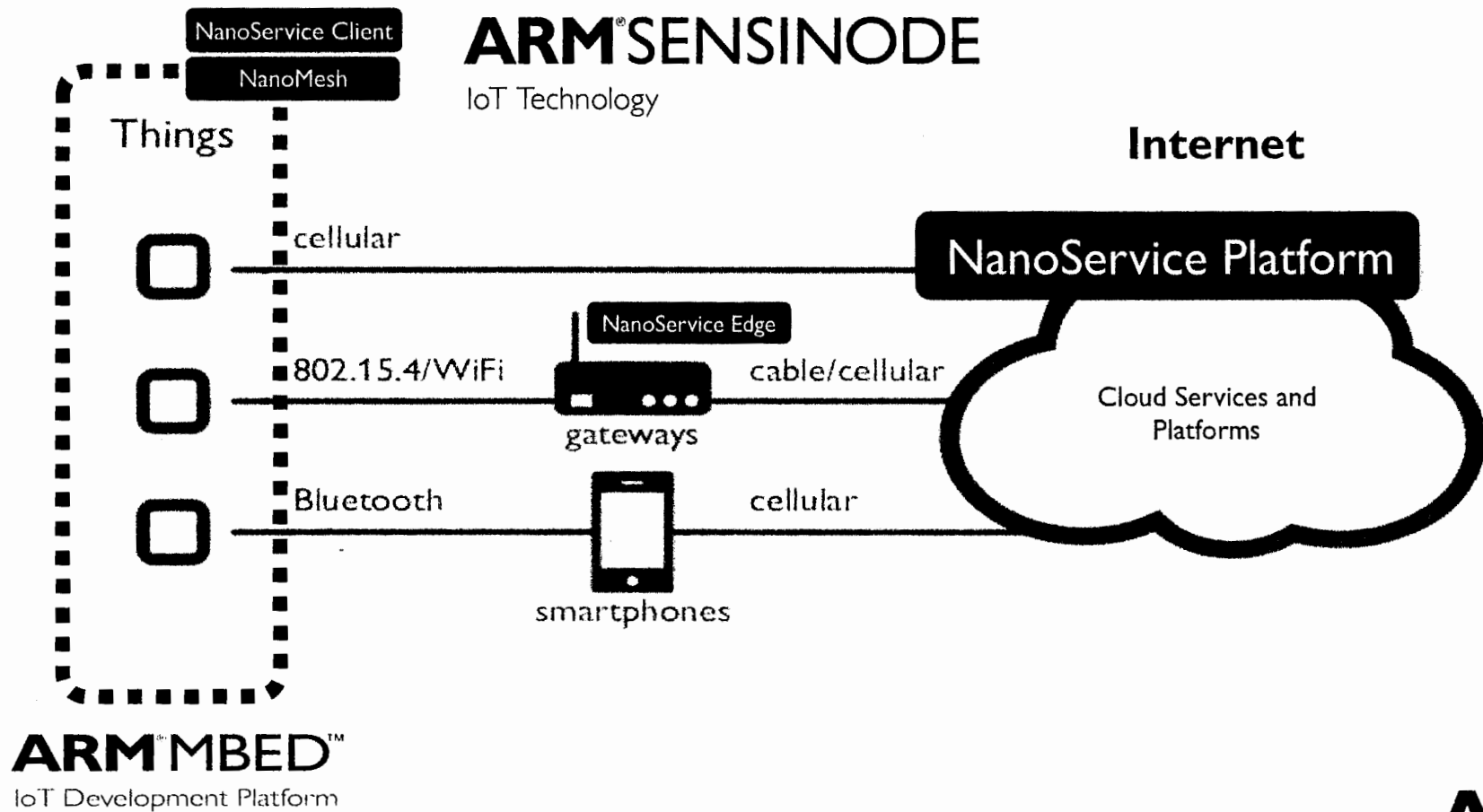
Connected Intelligence
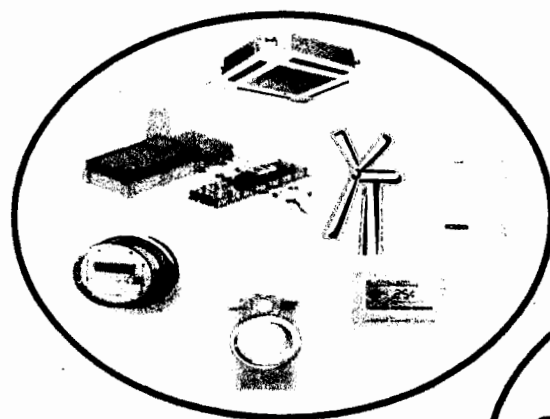
Smart energy
Power management
Servers, Industrial
Appliances

Human interface
Location aware
MEMS sensors
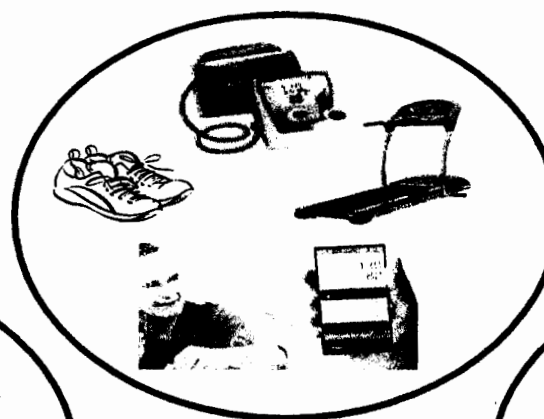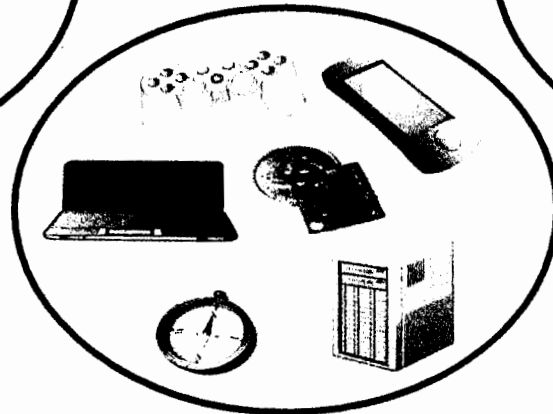
Health
Fitness
Medical devices

Smart homes
Security, Safety
Automotive
Electric vehicles
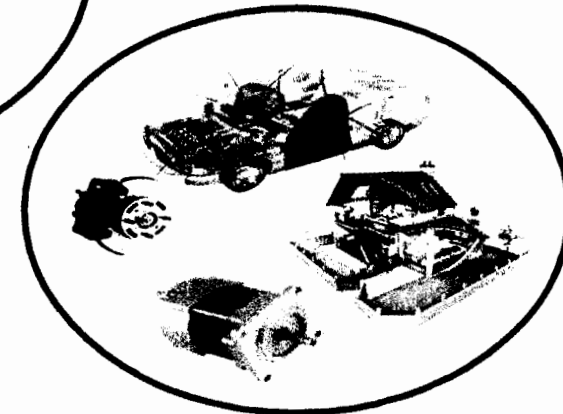
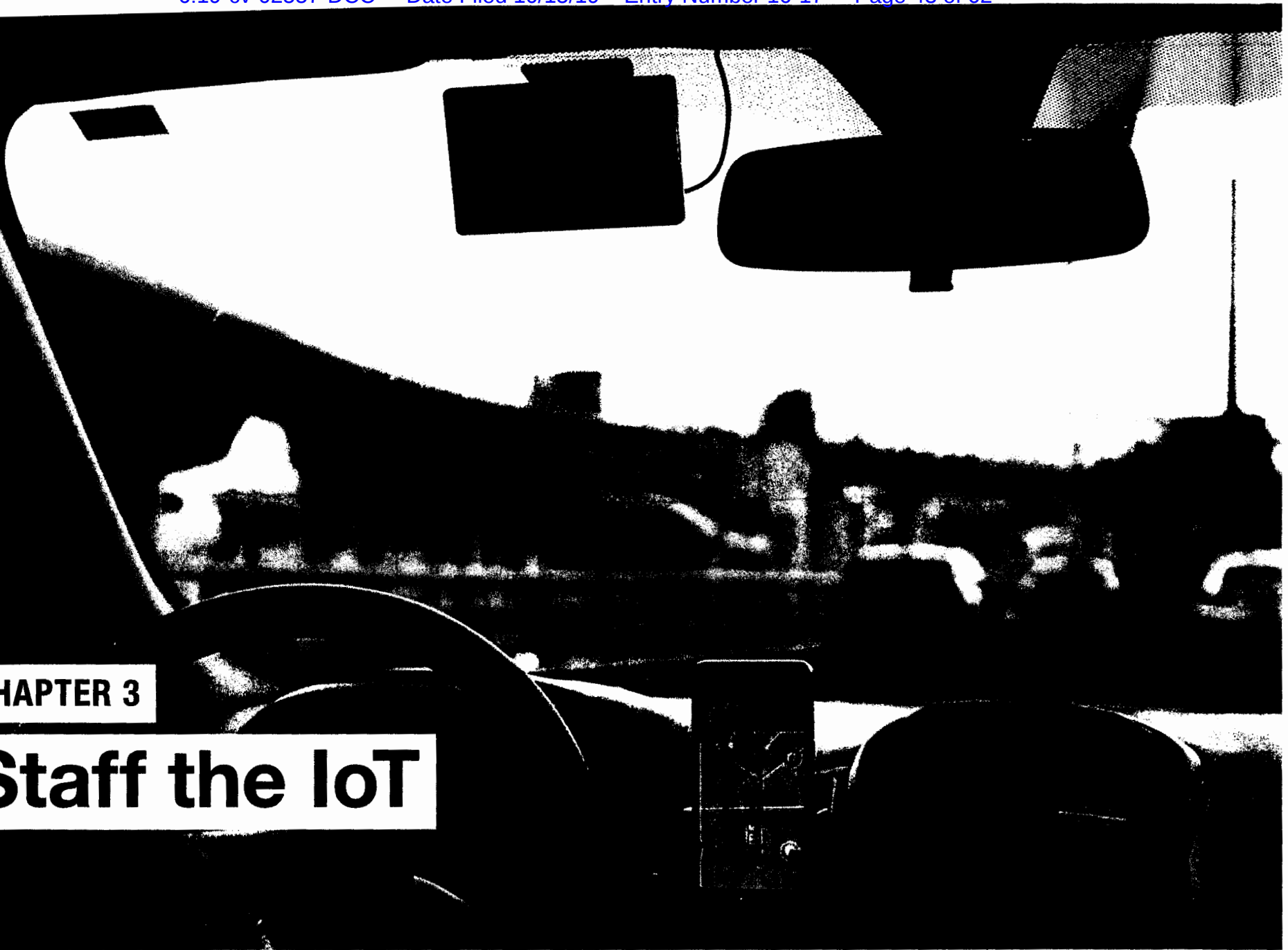## Sensing, processing, controlling, automating, communicating, connecting

ARM

3   CONFIDENTIAL   THE ARCHITECTURE FOR THE DIGITAL WORLD

Cloud-based home/enterprise automation
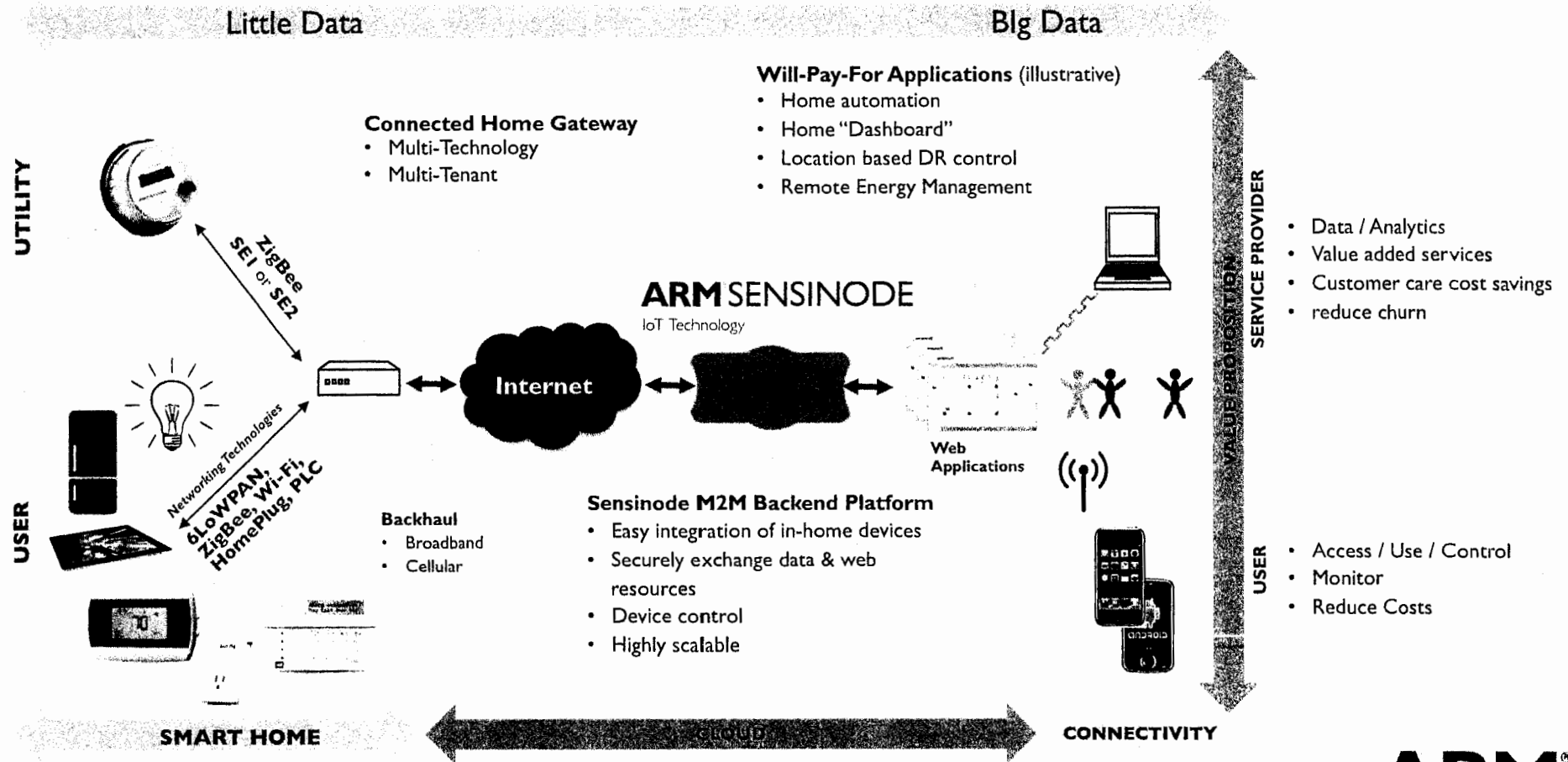
CHAPTER 3
Staff the IoT

Vehicle Internals: A Swarm of Sensors

Advanced Safety Vehicle

1. Road condition sensor
2. Magnetic sensor
3. Vehicle distance sensor
4. Forward obstacle sensor
5. Blind spot monitoring camera
6. Drive recorder
7. Side obstacle sensor
8. Air pressure sensor
9. Inside door lock/unlock
10. Rear obstacle sensor
11. GPS sensor
12. Airbag
13. Road-to-Vehicle / Vehicle-to-Vehicle communication system
14. Rear view camera
15. Water repelling wind shield
16. Seatbelt pretensioner
17. Driver monitoring sensor
18. Headup display
19. Steering angle sensor
20. Electronic control throttle
21. Electronic control brake
22. Fire detection sensor
23. Vehicle speed, acceleration sensor
24. Collision detection sensor
25. Pedestrian collision injury reduction structure
26. Electronic control steering
27. Message display system
28. Hands-free system

HISTORY

A U. S. DEPARTMENT OF HOMELAND SECURITY (BAA07-10)

"CELL-ALL: Ubiquitous Biological and Chemical Sensing"

CELL PHONE BIOLOGICAL AND CHEMICAL SENSING

Complainant's Proposal Submission dated 11/28/2007

Contracts to Qualcomm, LG, Apple, and Samsung

Official website of the Department of Homeland Security

U.S. Department of
Homeland Security

Science and Technology

Science and Technology

- <u>Our Work</u>
- <u>Strategic Directions</u>
- <u>Business Opportunities</u>
- <u>S&T News</u>
- <u>About S&T</u>
- <u>First Responders</u>

Cell-All: Super Smartphones Sniff Out Suspicious Substances

Years ago, if you wanted to take a picture, you needed a dedicated camera. You needed to buy batteries for it, keep it charged, learn its controls, and lug it around. Today, chances are your cell phone is called a "smartphone" and came with a three-to-five megapixel lens built-in—not to mention an MP3 player, GPS, or even a bar code scanner.

This Swiss Army knife trend represents the natural progression of technology—as chips become smaller and more advanced, cell phones continue to absorb new functions. Yet, in the future, these new functions may not only make our lives easier, they could also protect us—and maybe even save our lives.

The Cell-All initiative may be one such savior. Spearheaded by the Department of Homeland Security's (DHS) Science and Technology Directorate (S&T), Cell-All aims to equip your cell phone with a sensor capable of detecting deadly chemicals at minimal cost—to the manufacturer (a buck a sensor) and to your phone's battery life. "Our goal is to create a lightweight, cost-effective, power-efficient solution," says Stephen Dennis, Cell-All's program manager.

How would this wizardry work? Just as antivirus software bides its time in the background and springs to life when it spies suspicious activity, so Cell-All regularly sniffs the surrounding air for certain volatile chemical compounds.

When a threat is sensed, a virtual *ah-choo!* ensues in one of two ways. For personal safety issues such as a chlorine gas leak, a warning is sounded; the user can choose a vibration, noise, text message, or phone call. For catastrophes such as a sarin gas attack, details—including time, location, and the compound—are phoned home to an emergency operations center.

While the first warning is beamed to individuals—a grandmother taking a siesta or a teenager hiking through the woods—the second warning works best with crowds. And that's where the genius of Cell-All lies—in crowdsourcing human safety.

Currently, if a person suspects that something is amiss, he *might* dial 9-1-1, though behavioral science tells us that it's easier to do nothing. If he does do something, it may be at a risk to his own life. And as is often the case when someone phones in an emergency, the caller may be frantic and difficult to understand, diminishing the quality of information that's relayed to first responders. An even worse scenario: the person may not even be aware of the danger, like the South Carolina woman who last year drove into a colorless, odorless, and poisonous ammonia cloud.

In contrast, anywhere a chemical threat breaks out—a mall, a bus, subway, or office—Cell-All will alert the authorities automatically. Detection, identification, and notification all take place in less than 60 seconds. Because the data are delivered digitally, Cell-All reduces the chance of human error. And by activating alerts from many people at once, Cell-All cleverly avoids the longstanding problem of false positives. The end result: emergency responders can get to the scene sooner and cover a larger area—essentially anywhere people are—casting a wider net than stationary sensors can.

But what about your privacy? Does this always-on surveillance mean that the government can track your precise whereabouts whenever it wants? To the contrary, Cell-All will operate only on an opt-in basis and will transmit data anonymously. "Privacy is as important as technology," avers Dennis. "After all, for Cell-All to succeed, people must be comfortable enough to turn it on in the first place."

For years, the idea of a handheld weapons of mass destruction detector has engaged engineers. In 2007, S&T called upon the private sector to develop concepts of operations. Today, thanks to increasingly successful prototype demonstrations, the Directorate is actively funding the next step in R&D—a proof of principle—to see if the concept is workable.

To this end, three teams from Qualcomm, the National Aeronautics and Space Administration (NASA), and Rhevision Technology are perfecting their specific area of expertise. Qualcomm engineers specialize in miniaturization and know how to shepherd a product to market. Scientists from the Center for Nanotechnology at NASA's Ames Research Center have experience with chemical sensing on low-powered platforms, such as the International Space Station. And technologists from Rhevision have developed an artificial nose—a piece of porous silicon that changes colors in the presence of certain molecules, which can be read spectrographically.

Similarly, S&T is pursuing what's known as cooperative research and development agreements with four cell phone manufacturers: Qualcomm, LG, Apple, and Samsung. These written agreements, which bring together a private company and a government agency for a specific project, often accelerate the commercialization of technology developed for government purposes. As a result, Dennis hopes to have 40 prototypes in about a year, the first of which will sniff out carbon monoxide and fire.

To be sure, Cell-All's commercialization may take several years. Yet the goal seems imminently achievable: Just as Bill Gates once envisioned a computer on every desk in every home, so Stephen Dennis envisions a chemical sensor in every cell phone in every pocket, purse, or belt holster. If it's not already the case, our smartphones may soon be smarter than we are.

To request more information about this story, please e-mail st.snapshots@hq.dhs.gov (mailto:st.snapshots@hq.dhs.gov) .

"Proposal White Paper"

BROAD AGENCY ANNOUNCEMENT (BAA) 07-10

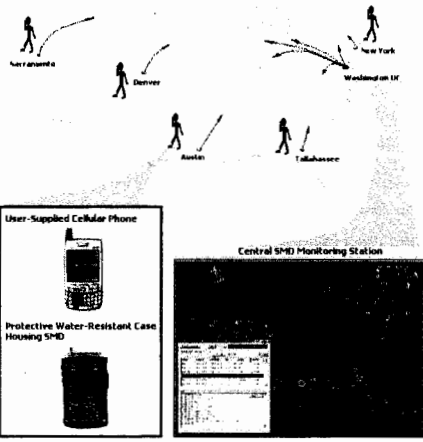*CELL-ALL Ubiquitous Biological and Chemical Sensing*

<u>Administrative and Technical Points of Contact:</u>

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Mauldin, SC 29662
864-288-5605 / 864-992-7104
lgolden5605@charter.net

Authorized Officer: _____

1

BAA Number: CELL-ALL BAA07-10 Title: CELL-SMD; Multi Sensor-Detection	Offeror Name: ATPG TECHNOLOGY, LLC Date: 11/28/2007
	Operational Capability: 1. Ability to effectively sense/detect chemical agents, reliably and securely report position and detection readings. Provide software applications to easily manage large scale network. Design allows for straightforward integration with existing cell phones Ability to graphically depict and filter live data. 2. Goal: ability to detect chemical or biological agents 99%. Goal: network throughput 99%. 3. Prototype SMD(cell phone case) target cost is $50 in mass quantities (excluding sensor) Competition among sensor developers will drive final cost. 4. Durable, inexpensive device, does not degrade performance of host device Makes extensive use of existing technology and builds upon completed spiral of a similar device.
Proposed Technical Approach: 1. Provides Sensor Monitoring Device (SMD) in a protective cell phone case. Easy to distribute/integrate with cell phone Viewer/Management SW provides hierarchical levels for information flow 2. Incorporate selected sensors into existing SMD functional prototype Manufacture prototype cell phone cases to accommodate SMD and sensors Enhance/scale existing cell phone, web and desktop support applications 3. First spiral complete, yielded functional prototypes – SMD, web, desktop & cell phone applications 4. Established working relationships with Otter Box and ECBC 5. CELL-ALL technical approach & rational taken from, "Multi Sensor-Detection and Lock Disabling System", (Patent Pending; Pub., 10-18-07; App. #: 11/397,118:)	**Schedule, Cost, Deliverables, & Contact:** One year Period of Performance, $1,000,000 Prototype and manufacture cell phone cases with integrated SMD, chemical and biological sensors Enhance/scale viewer/management software to support large sensor network **Deliverables:** Prototyped cell phone case containing SMD and sensors Cell phone & desktop viewer/management SW System demonstration of: sensor detection, alert transmitted through hierarchy and control center messages to SMD **Corporate Information:** ATPG TECHNOLOGY, LLC Larry Golden, CEO 522 Peach Grove Place Mauldin, SC 29662 Phone: 864-288-5605 lgolden5605@charter.net

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Executive Summary:

Two years ago, recognizing the danger that existed if a WMD was concealed, transported and deployed within our borders, ATPG embarked on the development of a multi-sensor, tracking and detection system. The first development spiral yielded a functional Sensor Monitoring Device (SMD) prototype and tiered communication applications to distribute, monitor and manage the multi-sensor SMD network information. The ubiquitous sensor network solution proposed in this white paper borrows heavily from the technology developed in spiral one. The tiered communication, viewer and management software applications were designed to be part of a large sensor network. For this application the software will be scaled and enhanced to accommodate the volume of traffic that would result from an extremely large sensor network. Our SMD was designed to provide as much flexibility as possible and communicates with a variety of sensors through an array of built-in standard interfaces (SPI, A/D, Serial, Bluetooth, I2C etc). This existing open architecture design affords us the opportunity to collaborate with the U.S. Army Edgewood Chemical and Biological Center (ECBC) to evaluate, test and acquire the most appropriate miniaturized chemical and biological sensors.

ATPG intends to utilize the hardware and software technology developed in spiral one as the basis for the ubiquitous sensor network. The form factor of the SMD will be re-engineered so that it can initially be housed in cell phone cases allowing straightforward integration with existing cell phones. The SMD, housed in the cell phone cases will use a Bluetooth channel to communicate with ATPG software hosted on the cell phone. This software will provide bi-directional communication between the SMD and cell phone. The cell phone software will additionally use email and SMS messaging services to communicate information to control centers. The software for managing the information from the sensor network will be architected in a way that provides a means to efficiently escalate information up the government hierarchy. The software will employ a large database back-end and where practical message routing rules will be implemented to allow for effective and efficient routing of sensor message traffic.

Utility to Department of Homeland Security:

ATPG's strategy of incorporating its existing SMD design into cell phone cases provides a means to quickly establish a massive sensor network nationwide. ATPG proposes modifying the SMD form factor so that it can be installed into the most common cell phone cases. When a person volunteers for the program they would receive a cell phone case along with an adapter cord that would connect to their existing phone charger; allowing the SMD and phone to charge simultaneously. A switch on the case will allow the volunteer to enable the device at their discretion. If a volunteer elects to participate in the program and their cell phone does not have an on board GPS, the SMD provided in the cell phone case will be equipped with one. The geographic position of the SMD/cell phone pair will be determined either by GPS, cell phone tower database and signal strength or by a Wi-Fi hotspot database. In the event current position cannot be determined, the device will use its last known good position fix for communications and the position will be flagged as such. Housing the SMD and sensors in a cell phone case provides a number of advantages. Since the SMD will draw all of its power from its own power source the only resources required from the cell phone will be for a dedicated Bluetooth channel and limited processing power to execute the cell phone software. Additionally the consumables

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in the cell phone case (battery, sensors etc.) can easily be switched out, or the entire case can be easily replaced. ATPG will be working with the Otter Box Company to design a cell phone case capable of housing the SMD and its sensors, providing a protective, water resistant case while maintaining complete cell phone interactivity. This approach will allow ATPG to easily and incrementally make changes to the host platform as the technology of the SMD and its sensors are miniaturized.

Technical Approach:

The creation, implementation and management of a massive sensor network will require a design approach that delivers a system solution. Every tier of the system is important and the end product must be manageable, provide redundancy and implement an open architecture wherever possible. The ATPG solution proposed here focuses on these requirements and delivers a design that translates into a straightforward, deployable sensor network system that can be distributed en masse.

At the lowest level, the SMD is engineered to communicate with a variety of sensors through an array of standard interfaces (SPI, A/D, Serial, I2C etc). This open architecture allows for easily integrating additional sensors into the device and expanding the range of hazardous agents detectable by the SMD. The SMD will continually monitor/control the attached sensors and communicate with the cell phone via a dedicated Bluetooth channel. When the SMD is activated by the user, a small software application installed on the phone will monitors the Bluetooth channel for detection alerts and also forward commands received from control centers to the SMD. The SMD will periodically send its position information to the control center. The position the SMD will report to the control centers is determined using a layered approach. Initially the SMD will look to the on-board GPS (if provided) to determine position. If the cell phone is equipped with a GPS the application on the cell phone will retrieve the position from its own GPS. When a GPS position cannot be determined, the position of the SMD and its user will be calculated based on a cell phone tower database, provided by the FCC and signal strength. If this does not yield a result, the Wi-Fi hotspot database will be utilized to determine SMD and user position. If all these options fail, the last known position can be augmented with the on board accelerometers to estimate the current position which will be reported to the control centers and annotated as a last position and a possible position. All information received by the cell phone application from the SMD will be forwarded to the control centers either through email or SMS messages if email is not available. The information transmitted will be encoded in XML and encrypted prior to transmission. When a user needs to be notified of information from a control center, the cell phone software will use either a ring tone or vibration to call the user's attention to the display. This solution of integrating the SMD into the cell phone case and installing a small software application on the volunteer's cell phone provides a means to easily modify and upgrade the sensor network system as advancements are made to sensor and SMD technology with minimal impact to the user.

The web and desktop software that support the sensor network is designed to support an escalating reporting hierarchy. At each level rules can be established in the message routing software to facilitate the transfer of alert information. Rules can also be established to assist in determining the area affected by an alert. In the event a chemical or biological agent is detected

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and reported, the software can automatically search for other sensors in a pre-defined area and command them to sample and report back. This information can then be used by first responders and local government to determine the impacted area and aid in creating a plan of action to cope with the event. The reporting hierarchy can be configured as needed but the current configuration sends notification to the local First Responder units, followed by City, County, State and Federal government. As the information works its way up the hierarchy rules at each level fire off to create events that notify necessary personnel at each level. The viewer/management software used at each level of the hierarchy is identical. How the system forwards and responds to data is configured in the message routing rules table. The desktop software uses Google Earth as a viewer and plots the position of the sensors and detections on the map. Filtering options are provided in the software to allow the screen to be decluttered. A hierarchical database of sensors reporting to the viewers at a given control center is maintained to allow simple manipulation of the sensor network. The software will allow the user to drill down into lower levels of the data by clicking on the images on the map or through the windows explorer like interface provided. The software will also allow commands and alerts to be sent to SMD enabled cell phones by clicking on the image or on its text representation. Each SMD representation on the map will display its unique identification number as its label and clicking on the icon will display the last set of data received by the control center. The sensor network data can also be made available to smart phones and PDAs running a variation of the viewer/management software. All data passed through this network will be encrypted and all database and user accounts will be protected by multiple layers of security to ensure the privacy of the volunteers and protect their location from foreign/unwanted access.

As an option all messages sent from the SMD to the control centers could receive notification of receipt; confirmation that the network is operating properly. This could be a built-in fail safe, which would allow the user to be notified first if detection occurred and the information could not be transmitted to a control center. In this scenario the user would be notified of the detection and could take action to leave the area and contact authorities through some other means.

Personnel and Performer Qualifications and Experience:

Larry Golden is the CEO of ATPG and will be the project manager for this program. Mr. Golden's invention and patent pending sensor monitoring device (Pub. 10-18-07; App. #: 11/397,118) will be used as the departure point for the development of the SMD. Mr. Golden's background is in industrial engineering and management. Larry's duties will include managing the schedule, budget and subcontractors providing the cell phone cases.

Harold Kimball is a software engineer with twenty years experience developing software applications, including embedded systems, operational flight programs, database applications, and web and desktop applications. Mr. Kimball will be the technical lead on this program as well as the lead software developer for the SMD applications. Over the past few years Mr. Kimball's focus has been on developing situational awareness applications, embedded device applications and aircraft simulation software. Mr. Kimball has a Bachelor's degree in Computer Science and is working on his Master's Degree in Artificial Life. Mr. Kimball recently had an

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article published describing a scalable disaster relief and communications infrastructure system he is developing to aid first responders and disaster relief personnel in their efforts.

Doug Cumbie is an electrical engineer and software engineer with six years experience developing embedded systems, web applications, situational awareness software and aircraft simulation software. Mr. Cumbie will be the lead Engineer on this program as well as the primary developer for the web and desktop applications. Over the past few years Mr. Cumbie has focused on embedded device development, situational awareness applications and aircraft simulation software. Mr. Cumbie holds Bachelor's degrees in both Computer Engineering and Electrical Engineering.

The Otter Box Corporation will provide custom cell phone cases for housing the SMD developed by ATPG. The Otter Box Corporation has extensive experience manufacturing and distributing custom cases for cell phones, laptops and PDAs. Their manufacturing and distribution experience will play a key role in the ability to efficiently develop, manufacture and distribute a custom cell phone case enveloping the SMD and providing a water resistant and protective case.

U.S. Army Edgewood Chemical and Biological Center (ECBC) will play a vital role in assisting ATPG with evaluating, testing and selecting the most appropriate miniaturized chemical and biological sensors available. ATPG and ECBC have a collaborative agreement in place ensuring ATPG of their services in sensor analysis and selection.

Commercialization and Capabilities:

ATPG will work closely with Otter Box and ECBC to determine the physical characteristics and requirements needed to create a custom cell phone enclosure for the selected sensors and SMD. ATPG will leverage Otter Box's manufacturing and distribution experience to enable ATPG to produce and deliver large quantities of custom cell phone cases. As mentioned previously the case will be designed and developed so that consumables can easily be swapped out or the entire cell phone case can be replaced. This approach ATPG is pursuing is the most economical and efficient way to mass distribute a sensor network; providing low risk and minimal impact to volunteers of the program. Becoming part of this volunteer network would be a simple process and would only require end-users to; elect to become a volunteer, indicate which type of cell phone they currently use and upon receipt of the new cell phone case commence holstering the cell phone in the case wherever they go. As an option and to solicit interest in the program, volunteers could be provided software applications. These applications could potentially access tracking information of the volunteer's phone and the volunteer's family members' phones; or a moving map application could be provided to enable navigation through the cell phone. Mr. Kimball and Mr. Cumbie have many years experience developing and distributing code to demanding end users. Both individuals have experience providing Situational Awareness and OFP software to the Air Force Special Operations Command (AFSOC) for all fixed wing Special Operations Forces (SOF) aircraft. Additionally, Mr. Kimball worked for Manheim Auctions, an international organization with a large customer base and participated in the development and distribution of Manheim's software applications.

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One method ATPG conceived for fielding the sensor network and implementing its widespread use would be to conduct a pilot program for the nearly 30 million government employees, border patrol personnel and government contractors. These individuals generally work in what would be considered high value target areas. Providing these employees with cell phone cases equipped with the SMD and its sensors would immediately give the sensor network nationwide coverage in many areas that would be likely targets of a terrorist attack. In addition to gaining nationwide coverage; if this pilot program extended to all government employees and its contractors around the world, the network would have the ability to monitor U.S. interests globally.

Costs, Works and Schedule:

The budgeted cost for this development is $1,000,000, with a projected period of performance of one year. ATPG will simultaneously commence four primary tasks upon contract award.

1) ATPG will work with ECBC to evaluate, test and select the most appropriate chemical and biological miniaturized sensors available (4 month effort, $17,137)).

2) ATPG will research and determine the three most commonly used phones capable of being part of this sensor network and work with Otter Box to design and manufacture cell phone cases to house the SMD and sensors (4 month effort, $45,000).

3) ATPG will enhance/scale the software applications to support the potentially large volume sensor network that will comprise the Cell-All ubiquitous system (7 month effort, $500,000).

4) ATPG will restructure and scale down the SMD so it can be accommodated in the cell phone case. After month 7, integration and testing of the Cell-All system will commence. The system will be documented (block diagrams, wiring diagrams, and theory of operation manual) and a demonstration date will be scheduled (12 month effort, $437,863).

Prototype cases housing the SMD and sensors, cell phones and viewer/management software executables will be delivered upon project completion.
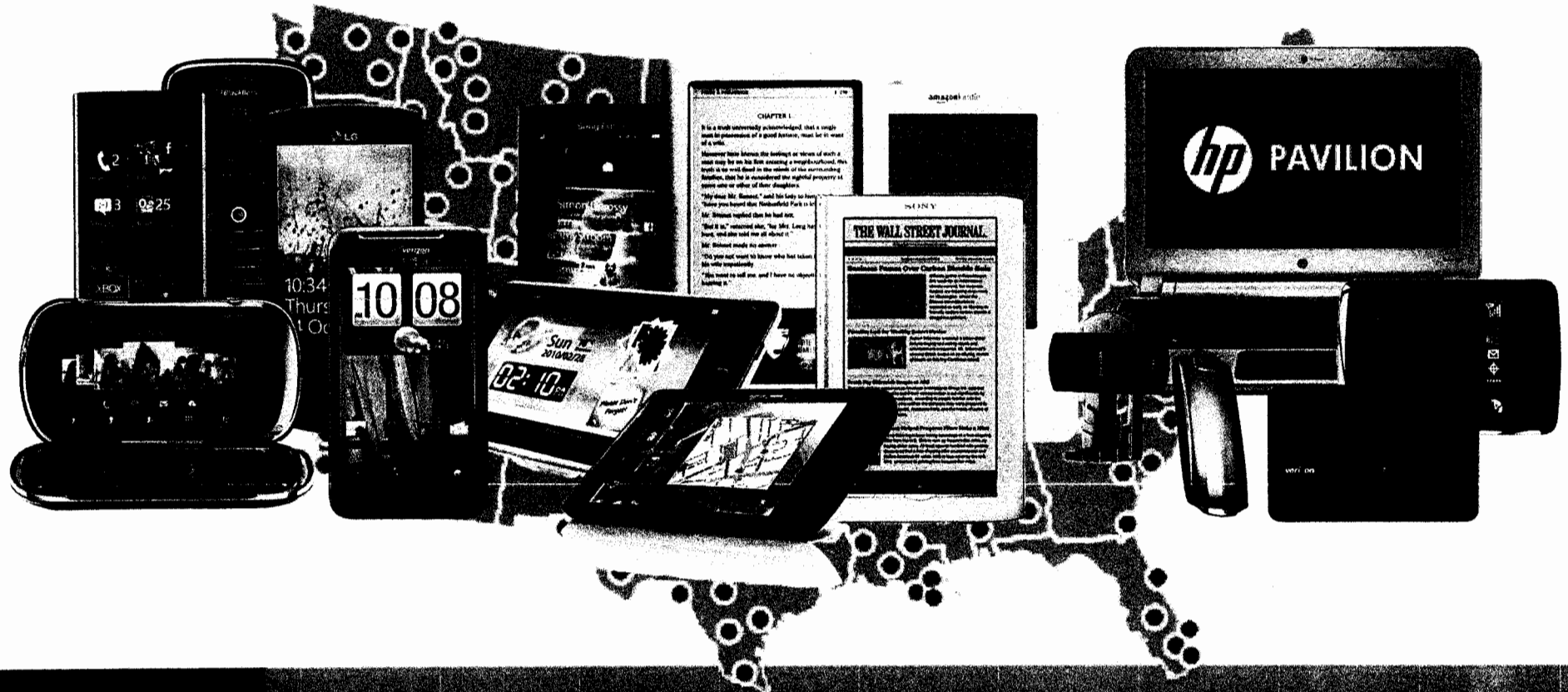
Small Business Considerations:

This white paper is submitted from a minority owned small business.

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QUALCOMM

DHS asked, "what if…"

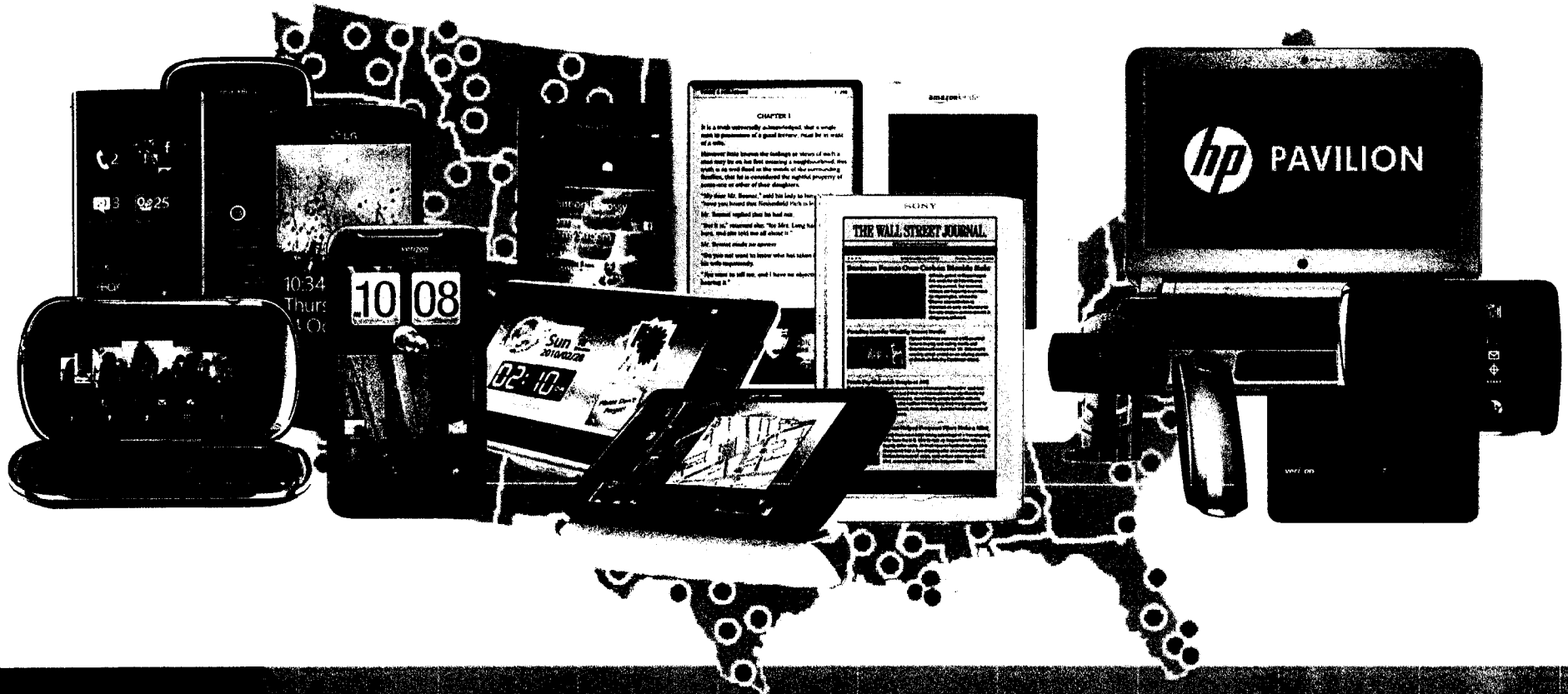…we wanted to provide high impact ubiquitous technology for CBRNE sensing?

QUALCOMM   DEVELOPED IN PARTNERSHIP WITH THE **U.S. Department of Homeland Security Science & Technology Directorate**
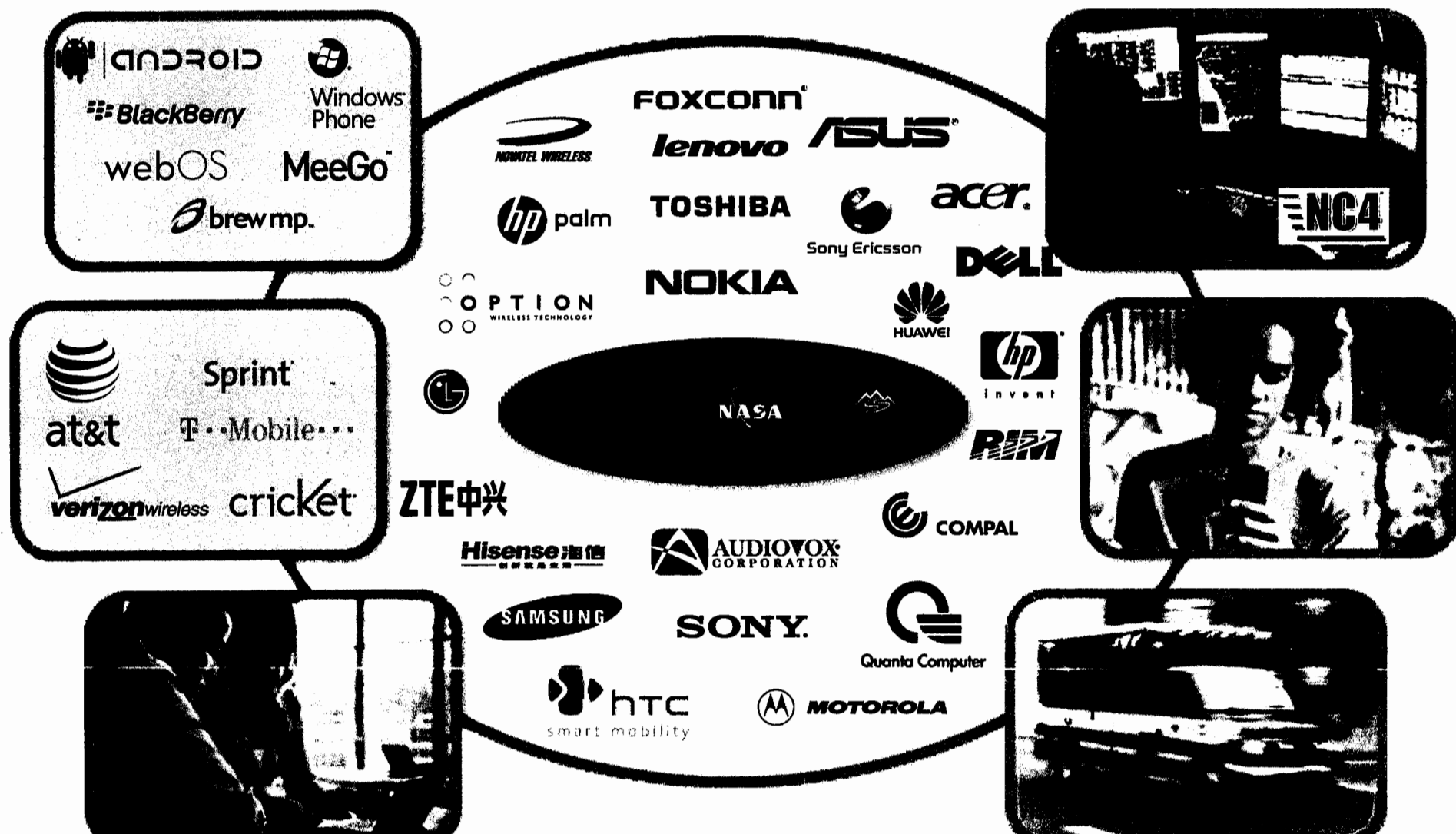
DHS asked, "what if…"

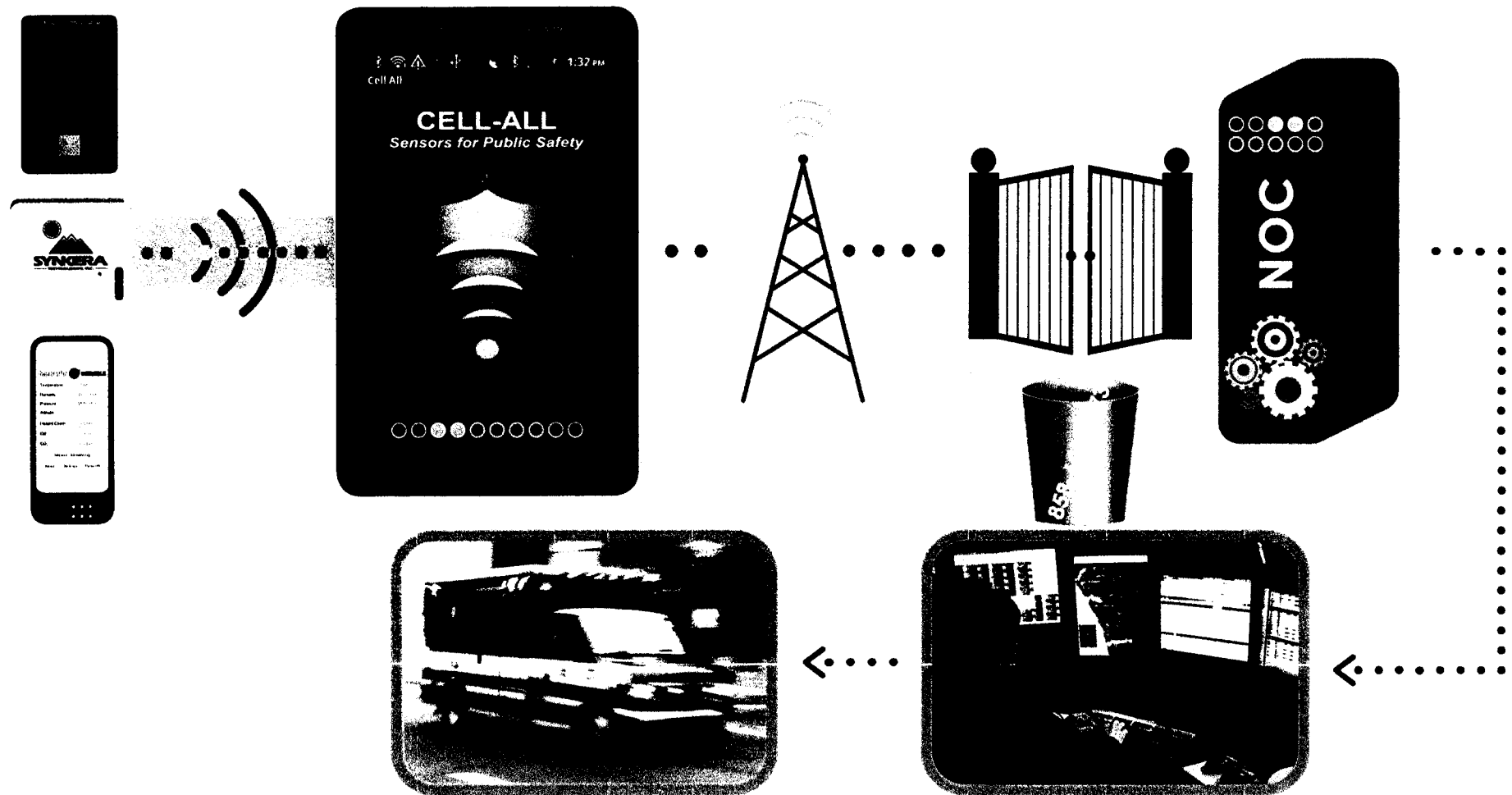## Answer: Use commercial cellular phone ecosystem and commercial networks
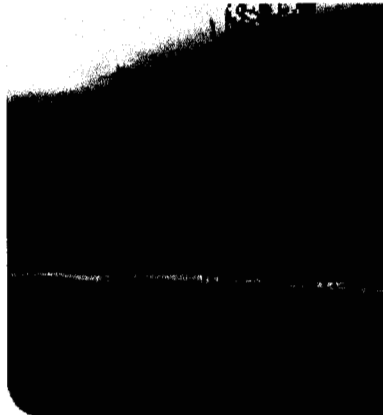
Who are the necessary stakeholders?

How does it work?

What's left to do?

FIRST RESPONSE COMMUNITY

- Seamless integration to their workflow

- Training in the use of Cell-All

BUSINESS

- How to make it attractive for all stakeholders

SYSTEM

- First responder and user trials

- Performance and scalability

- Enhance security for commercial use

- Refine algorithm

SENSORS

- Manufacturing Volumes

- Reproducibility

- Power

- Integration